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LANDSAT DATA CONTINUITY MISSION

SPECIAL CALIBRATION TEST REQUIREMENTS

(thermal band addendum)

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National Aeronautics and Space Administration

Goddard Space Flight Center
Greenbelt, Maryland

1) **This document mirrors the structure of the previously released Special Calibration Test Requirements (SCTR) document and in cases uses the same wording for the thermal option as for the reflective bands. Comments previously received on the reflective band SCTR have not been considered in the development of this document. They will be considered in the next release where they will also be considered for the reflective band requirements. If you have already made a comment on a corresponding section of the reflective band requirements, you do not need to repeat it here, unless it is peculiar to the thermal option.**
2) **The stray light and ghosting requirement that is referenced in this SCTR thermal band addendum is being added to the thermal band imaging requirements**

1. Introduction (as previously released)
2. General Test Requirements (as previously released)
3. Reflective Band Pre-flight Test Requirements (as previously released)
4. Reflective Band On-orbit Commissioning Phase Test Requirements (as previously released)

5. Thermal Band Pre-flight Test Requirements

5.1) Spectral test requirements

Prior to launch, the contractor shall:

5.1.1) Characterize the relative spectral radiance response for each band of the instrument and the variation of this response within the band.

i. The relative spectral radiance response of a representative sample of detectors, the spectral transmission or reflectance of a representative sample of the optical elements and the spectral transmission of the spectral bandpass filters shall be measured at the component level. These measurements shall be performed at the expected operational temperatures and angular conditions.

ii. The spatial variability in relative spectral response shall be characterized at the component or focal plane level.

iii. The in-band (between 0.01 relative response points) relative spectral radiance response shall be measured at the integrated instrument level under simulated on-orbit operating conditions (vacuum and focal plane temperatures). If only a representative sample of detectors are tested, then this sample shall include at least 5% (TBR) of the detectors in each band uniformly distributed across the focal plane, i.e., samples from center and edges of each sensor chip assembly.

iv. The out-of-band relative spectral radiance response of the instrument shall be determined down to a sensitivity of 4 (TBR) orders of magnitude (below the peak in-band value) across the wavelength range of the sensitivity of the detectors used in the particular band. This determination shall be based on measurements of the optical elements as well as measurements made after detectors are mated to filters or at higher levels of assembly. The detector/filter measurements shall be made under operational temperature and angular conditions with adjacent bands illuminated.

5.1.2) Characterize the stability of the spectral transmission of the spectral band bandpass filters under vacuum conditions from initial exposure to 7 days at their expected operating temperature.

5.2) Spatial test requirements

Prior to launch, the contractor shall:

5.2.1) Characterize the spatial edge response based on measurements at the integrated instrument level under simulated on-orbit operating conditions (vacuum and temperatures) for a representative sample, i.e., 11 field angles (Scale Factors of Field of View (FOV): -1, -.89, -.77, -.63, -.44, 0, .44, .63, .77, .89, 1.0) across the entire FOV in all bands. Examine edge spread response data for possible crosstalk between spectral bands on the same focal plane.

5.2.3) Characterize the stray light rejection and internal light scattering and thermal emission of the instrument based on measurements at the component level or above and analysis. The stray light model shall be developed using a Government-approved non-sequential ray trace method, e.g. ASAP, APART, GUERAP, Trace Pro. The stray light model shall encompass the spacecraft and other spacecraft instruments and the entire optical system, including baffles and the focal plane, detectors and mounting devices. Collect data at the integrated instrument level sufficient to look for instrument stray light effects not predicted by the stray light model. Characterize all applicable spectral bands to allow for possible improvements to the instrument stray light model. Included within this general stray light characterization and analysis special test requirement are measurements and analysis to confirm a more specific type of stray light, which is addressed in the ghosting system specification requirements. In tests at the integrated instrument level associated with this requirement verification, the minimum size object diameter for testing will be equivalent to an enclosing diameter of 1/10 of the FPA across-track FOV.

5.3) Radiometric test requirements

Prior to launch, the contractor shall:

5.3.1) Radiometrically calibrate all detectors at the integrated instrument level in absolute units under simulated on-orbit operating conditions (vacuum and focal plane temperature). Characterize the radiometric sensitivity model for the instrument thermal environment, i.e., contributions of instrument emitted radiance to the instrument response. Collect sufficient calibration data sets and characterization data to demonstrate that the calibrated data will meet the absolute radiometric accuracy, noise equivalent temperatures, and radiometric stability requirements on orbit.

5.3.2) Determine the mathematical equation(s) to convert the instrument output in DN to input radiance in W/m^2-sr-μm. Demonstrate the validity of the equation(s) with integrated instrument level measurements for a sampling of detectors.

5.3.3) Characterize the on-board calibration source(s) for on-orbit use across the range of focal plane view angles. This shall include the directional emissivity and spatial uniformity of the blackbody(s). This shall include characterization of the stability of the blackbody(s) over a minimum of 40 minutes.

5.3.4) Characterize the noise equivalent temperatures (NEdT) of all detectors with integrated instrument level measurements under simulated on-orbit operating conditions (across the on-orbit sensor temperature range and in vacuum) and across the dynamic range of the instrument.

5.3.5) Characterize the stability of the instrument response under simulated on-orbit operating conditions (across the on-orbit sensor temperature range and in vacuum) across 40 minutes or the planned time between instrument calibrations, whichever is longer.

5.3.6) Characterize the detector bias and gain stability across on-off cycling of the instrument.

5.3.7) Characterize 1/f noise parameters baseline by measuring long blackbody collects under simulated on-orbit operating conditions (across the on-orbit sensor temperature range and in vacuum). Test includes, at a minimum, one 30-minute continuous data collect.

5.3.8) Characterize the coherent noise of the instrument with spacecraft level measurements under simulated on-orbit operating conditions including contributions from the spacecraft (across temperature range and in vacuum).

5.3.9) Characterize the bright target recovery and pixel-to-pixel electrical crosstalk of the instrument by focal plane level or above level measurements.

5.3.10) Provide and maintain a detector operability status list which include dead, inoperable, and out-of-spec detectors for each band.

5.4) Geometric test requirements

Prior to launch, the contractor shall:

5.4.1) Characterize the instrument's lines-of-sight (LOS) via measurements of all detectors LOS relative to the instrument coordinate system.

5.4.2) Characterize the relative stability of the detector lines of sight by measuring the relative locations of a selected set of detectors from each band and each SCA at the nominal, maximum and minimum expected operating temperatures, to an accuracy ≤ 3[TBR] μrad (1-sigma), at integrated instrument or observatory level, post-vibration. The selected set of detectors shall include, at a minimum, the first, middle, and last detector in each row, if multiple rows of detectors are provided e.g., due to even/odd detector staggering, from each band on each SCA.

5.4.3) Measure the alignment of the instrument optical axes relative to the observatory Attitude Determination System reference.

5.4.4) Verify the integrity of the instrument-to-recorder data path by demonstrating the ability to accurately reconstruct and register images in both thermal bands from data collected under conditions that simulate the on-orbit target motion. This demonstration may be performed in segments over the full FOV of the instrument.

5.4.5) Characterize the detector-sampling timing pattern via measurement of any detector-specific electronic delays, sample phasing (e.g., even/odd detector timing offsets), and frame rate (i.e., time between samples) for each detector.

6. On-Orbit Commissioning Phase Test requirements

6.1) Spatial tests requirements

During the Commissioning phase, i.e., prior to Initial Operational Capability, the contractor shall:

6.1.1) Examine the stray light and ghosting of the instrument using multiple stressing targets such as lava flows and the moon.

6.2) Radiometric test requirements

During the Commissioning phase, i.e., prior to Initial Operational Capability, the contractor shall:

6.2.1) Demonstrate the absolute radiance calibration procedure generates data meeting performance specifications. Validate the radiometric sensitivity model for the instrument thermal environment, i.e., the contributions of instrument emitted radiance to the instrument response.

6.2.2) Characterize any variations in detector responsivity over a minimum of 2 instrument out gassing cycles, if required.

6.2.3) Characterize the relative detector response for detectors within a band and update the calibration parameters to correct pixel-to-pixel non-uniformity as necessary.

6.2.4) Characterize both the coherent and total noise of the instrument at a minimum of three radiance levels between 260K and 330K at least twice.

6.2.5) Characterize: 1) the calibration stability and 2) the 1/f noise parameters for all detectors, over 3 orbits, at least twice.

6.2.6) During the imaging-related maneuvers, e.g. lunar scans and off-nadir views for the reflective bands, characterize the stability of the thermal bands and the thermal calibration sources.

6.2.7) If Landsat-7 is still operational, collect data of common ground targets within 20 minutes of the Landsat-7 ETM+ acquisitions.

6.2.8) Characterize the bright target recovery and crosstalk of the instrument.

6.2.9) Update the detector operability status list with newly identified dead, inoperable, and out-of-spec detectors for each band at least twice.

6.3) Geometric test requirements

During the Commissioning phase, i.e., prior to Initial Operational Capability, the contractor shall:

6.3.1) Characterize the instrument to Attitude Determination System Reference alignment.

6.3.2) Characterize the thermal band detector arrays lines of sight relative to each other and to the reflective bands, using ground targets, at least twice.